upstream migration of adult fall-run chinook salmon (i.e., attraction flows).

- Minimize changes in the timing and volume of freshwater flows in the rivers to the Bay-Delta.
- To the extent consistent with CALFED objectives, provide unrestricted access of adult splittail to spawning habitats from December to July by maintaining adequate flow and water quality, and minimizing disturbance and flow disruptions.
- To the extent consistent with CALFED objectives, reduce the effects on splittail from changes in reservoir operations and ramping rates for flood control.
- To the extent consistent with CALFED objectives, ensure that the Yolo and Sutter Bypasses are flooded during the spawning season at least once every 5 years.
- To the extent consistent with CALFED objectives, increase the frequency of flood bypass flooding in non-wet years to improve splittail spawning and early rearing habitat.

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◆ CENTRAL VALLEY STREAM TEMPERATURES

INTRODUCTION

Water temperatures in Central Valley rivers and streams and in the Bay-Delta are determined by the natural heating and cooling process of water bodies. Water temperature is controlled by water source (i.e., dam releases, runoff, and discharges), surface water and groundwater inflow, geomorphology (e.g., depth), tides, riparian shading, water clarity, and, most often, ambient air temperature. Water temperature is a major factor in habitat suitability for aquatic organisms. Unnaturally high water temperature can become a stressor to many aquatic organisms.

Major factors that limit water temperature contributions to the health of the Bay-Delta are disruption of historical streamflow patterns, loss of riparian vegetation, stored water releases from reservoirs, and discharges from agricultural drains.

RESOURCE DESCRIPTION

Natural biochemical processes, as well as aquatic organism physiology and behavior (e.g., respiration, feeding, growth), are partially controlled by water temperatures. Many native aquatic organisms, such as chinook salmon, depend on cool water for spawning, rearing, and migrating. For example, adult salmon migrating upstream through the Delta and into the rivers are stressed when water temperatures reach into the 58 to 65° Fahrenheit (F) range, which may delay migration and spawning, which in turn may affect egg quality and potential production of juvenile salmon.

High fall water temperatures in the Delta may delay upstream migration of fall-run chinook salmon from the Bay into and through the Delta. High spring water temperatures in the rivers and Delta may stress young chinook salmon migrating downstream to the ocean. High summer water temperatures in the Sacramento River near Redding may stress the eggs and fry of winter-run chinook salmon. Unusually high water temperatures in periods of drought were primary factors in historical declines of salmon and other fish species.

Although stream temperatures fluctuate daily, seasonally and in response to meteorological conditions (e.g., air temperature and the amount of sunshine), many important ecological functions are dependent on a relatively narrow temperature range. For example, salmon and steelhead require 54°F to 57°F to spawn and egg development requires water temperatures below 57°F. Growth of young salmon and steelhead is generally optimal in the 50-60°F range.

Stream temperatures regulate important ecosystem functions including:

- Algae blooms,
- Aquatic invertebrate reproduction and growth,
- Fish migration,
- Fish spawning,
- Fish development and growth,
- General well-being of aquatic organisms,
- Metabolism and behavioral cues of aquatic organisms,
- The amount of dissolved oxygen (DO) available in the water body, and
- Rates of organic material decay and nutrient recycling in aquatic habitats.

The ability to control water temperature in rivers and the Delta is limited because water temperature is most strongly influenced by air temperature. Some temperature regulation is available through control over streamflows, discharges of warm water into rivers and the Delta, and the extent of inundation and shading of floodplains. Temperature can be controlled to some extent below major Central Valley reservoirs by the selective release of warm or cold water from different depths behind the dams.

Construction and operation of Shasta Dam dramatically altered the flow regime and thermal characteristics of the Sacramento River (Hallock 1987). Hallock observed that water released in the spring was often too cold for rapid growth of juvenile fall- and late-fall-run chinook salmon, and that water released in August and September was often too warm for successful spawning and incubation of spring- and winter-run chinook salmon eggs and alevins.

The recently completed Shasta Dam Temperature Control Device allows operators to release water from different depths or combinations of depths to regulate the temperature in upper portions of the lower Sacramento River. Intake shutters on Folsom Dam allow water to be released from three different layers into the lower American River. Most large reservoirs have only one deep water intake in the cold water zone of the reservoir. The amount of cold water that can be released from Central Valley reservoirs is limited, especially in drought years.

Temperatures in Central Valley streams follow a seasonal pattern. Water temperatures are controlled primarily by meteorological conditions (indicated by air temperature fluctuations). Although Central Valley air temperatures range from 30°F to over 100°F, stream temperatures generally range from about 40°F to 80°F. Coolwater fish generally require stream temperatures lower than 65°F. Lower temperatures are easily achieved in high mountain streams but are more difficult to maintain in streams at lower elevations and along the valley floor. Releases from major reservoirs and groundwater (e.g., springs) are two important seasonal sources of cool water.

Maintaining cool water below reservoirs is especially important because salmon and steelhead are blocked from reaching their historic spawning and rearing grounds in headwaters in these rivers.

The water from many Central Valley streams is impounded by large multipurpose reservoirs (as well as by smaller diversion dams) that limit the upstream migration of anadromous fish into higher elevation tributaries historically used for spawning and rearing. The operations of these reservoirs can be used to maintain adequate stream temperatures in the segments immediately downstream of the reservoirs, but these temperature control operations must be integrated with other water management objectives.

Stream temperature is a major habitat condition that exerts a strong influence on many biochemical processes. Temperature controls the maximum concentration of dissolved oxygen (DO) in water. Fish and other aquatic organisms require adequate amounts of DO in water to survive. The maximum DO concentration is higher at 50°F than at 70°F. Higher temperatures also increase the decay of oxygen-consuming organic materials further reducing total DO concentration.

Many fish behavioral and physiological functions, such as spawning, are controlled in part by temperature. Fall-run salmon begin to spawn when stream temperatures fall to 60°F. Salmon-egg survival is a strong function of temperature, declining to near zero at temperatures greater than 62°F. Successful holding of adult winter-run and spring-run salmon until spawning requires temperatures below about 60°F. Temperatures below 65°F are considered necessary for successful steelhead rearing.

Controlling water temperatures on regulated streams is complex. The Sacramento River Winter-run Chinook Salmon Recovery Team reported that water temperatures in the upper Sacramento River result from the complex interactions of: (1) ambient air temperature, (2) volume of water, (3) water temperature at release from Shasta and Trinity dams, (4) total reservoir storage, (5) location of reservoir thermocline, (6) ratio of Spring Creek Powerplant releases to Shasta Dam release, and (7) tributary inflows (NMFS 1997).

Wang (1986) reported that delta smelt spawn in fresh water at temperatures of 44 to 59°F. In recent years, ripe delta smelt and recently hatched larvae have been collected at temperatures of 59 to 72°F, so it is likely that spawning can take place over the entire 44 to 72°F range (U.S. Fish and Wildlife Service 1996).

Splittail trawl catches in Suisun Marsh are highest in summer when salinities are 6 to 10 parts per thousand and water temperatures are 59 to 73 °F (U.S. Fish and Wildlife Service 1996).

Cool temperatures also affect the growth rate of fish. For example, at 50°F, about 100 days are needed for rearing juvenile fall-run salmon to reach a size suitable for outmigration (3 inches). Rearing at 45°F would require about 140 days; rearing at 55°F would shorten the growth period to about 80 days. Fish spawning in different streams with differing temperature regimes will, therefore, have different timing and duration for spawning, growth, and migration.

Hatchery temperature objectives are often targeted to provide maximum growth without increasing mortality from excessive rates of respiration and diseases that are more prevalent at higher temperatures. Coldwater virus disease (IHN) is often a substantial problem at temperatures below 50°F. Salmonid temperature objectives in hatcheries are therefore generally within the 50-60°F range, which is much lower than the full range of Central Valley water temperatures.

VISION

The vision for Central Valley stream temperatures is to restore natural seasonal patterns of water temperature in streams, rivers, and the Delta to benefit aquatic species by protecting and improving ecological processes that regulate water temperature and reducing stressors that change water temperature.

Appropriate water temperatures will provide suitable fish spawning, holding, and rearing habitat conditions and contribute to the recovery of species and overall health of the Bay-Delta.

Natural temperature conditions in Central Valley streams vary along a continuum on a "longitudinal gradient" from the mountain headwaters to meandering lowland rivers, and on to the Delta. Therefore, restoration needs for stream temperatures vary for different streams and stream segments. These needs will vary by stream and stream segment, depending on existing conditions. The needs and opportunities to protect and manage Central Valley stream temperatures will depend on the conditions of the stream channel and riparian corridor, as well as the existing water supply (i.e., reservoir storage) of each tributary stream.

A primary restoration need will be to maintain relatively low water temperatures in summer and fall for anadromous fish populations in the upstream portion of each major tributary to the Delta, especially those tributaries with larger foothill reservoirs and impassable dams. These low water temperatures are particularly important for the survival of juvenile steelhead. In relatively wet years, with full reservoirs and high reservoir releases for downstream diversions, water temperatures below the major Central Valley reservoirs are maintained within the 50-60°F target range. However, as available water supply declines (i.e., in drier years), the ability to maintain sufficient carryover storage to sustain the release of cool water and to release sufficient flows to control downstream temperatures for salmon and steelhead rearing is substantially reduced. Sustaining adequate temperatures below reservoirs and power diversion dams is needed to provide coolwater anadromous fish habitat within the existing Central Valley multipurpose water resources management framework. Flexibility in managing stream temperatures will be an important ingredient in the successful restoration of Central Valley natural resources.

Particular attention has been given to water temperatures below Keswick Dam because this area is the only remaining spawning habitat on the Sacramento River for winter-run chinook salmon. Extremely warm water in 1976 and 1977 was likely a major cause of the decline in winter-run chinook salmon. Red Bluff Diversion Dam likely contributed to the sustained low population of winter-run chinook throughout the period following the 1976-77 drought, even when water temperature impacts were moderated. Only very low populations of winter-run salmon have been maintained since this drought event, during which Shasta Reservoir storage declined to less than 1 million acre-feet. The California Department of Fish and Game (DFG) and the Anadromous Fish Restoration Program (AFRP) suggest that Shasta Reservoir carryover storage should not drop below 1.9 million acre-feet to ensure an adequate supply of cold water for release in summer and fall. The Temperature Control Device, completed in 1997, provides additional flexibility in temperature control and conserving cooler reservoir waters through the summer and fall.

The State Water Resources Control Board (SWRCB) has added water temperature requirements below Keswick Dam (and in the Trinity River below Lewiston Dam) to the water rights for Shasta and Clair Engle Reservoirs. A multiagency Sacramento River Temperature Task Force is responsible for the adaptive management of Sacramento River water temperatures. It reports to SWRCB on the effects of its temperature management and the resulting winter-run chinook spawning and rearing success each year. These water management decisions are more difficult in years with limited water supply.

Whiskeytown Reservoir releases of water into Clear Creek, a tributary to the Sacramento River, are sufficiently cool to support salmon and steelhead. However, since 1965, insufficient streamflows and fish-passage problems have prevented this potential habitat from supporting many fish. Low-level outlets can be used for releases to Clear Creek. Efforts to manage temperatures in Clear Creek could be implemented as on the Sacramento River.

The temperature of Lake Oroville releases to the Feather River is controlled (e.g., temperature control panels) for the Feather River Hatchery and the "low-flow" channel. The objective is to maintain temperature for natural spawning and holding of spring-run salmon and steelhead. Carryover storage, sufficient to maintain low fall water temperatures, is limited during droughts. The California Department of Water Resources (DWR) is exploring operations of the Oroville-Thermalito complex to determine whether improved stream temperature controls can be achieved. As at Shasta Dam, additional means for controlling temperature are needed for these adaptive management efforts to provide optimal water temperatures within the overall water management framework. One such means would be additional storage water dedicated to temperature control in the Feather River below Lake Oroville and Thermalito Reservoir.

Yuba River water temperatures are considered well suited for salmon and steelhead below Englebright Dam (the first impassable dam), but flows and riparian vegetation have been insufficient to maintain target temperatures below the Daguerre Dam, the major water diversion dam on the lower Yuba below Englebright Dam. The Yuba County Water Agency is evaluating the temperature control potential of New Bullards Bar Reservoir (a major storage reservoir upstream of Englebright Lake on the North Fork of the Yuba River) and is working with AFRP and DFG to develop an adaptive management strategy for Yuba River flows and temperatures. Again, like at Shasta and Oroville, additional storage dedicated to water temperature control and possibly the addition of temperature control devices on major storage reservoirs could improve the water temperature conditions on the lower Yuba River.

Many of the upper Sacramento River tributaries are largely nonregulated. Water temperatures on these stream and in the Sacramento River at their confluence could be improved by managing water diversions and improving riparian vegetation.

The U.S. Bureau of Reclamation (Reclamation) has recently modified the Folsom Dam temperature control panels to provide some additional temperature management potential; however, the relatively low storage capacity of Folsom Reservoir limits the ability to control temperatures at the Nimbus Hatchery and in the lower American River. Additional storage dedicated for water temperature and potential improvements to temperature controls at Nimbus Dam could improve water temperatures in the lower American River.

Temperatures in the San Joaquin River tributaries (Mokelumne, Stanislaus, Tuolumne, and Merced rivers) are controlled by a combination of cold-water reservoir releases and streamflow management. Although initial efforts to monitor and control water temperatures on these rivers have begun, the upstream segment of each may require additional reservoir and flow management actions. Unlike other most other dams in the Central Valley, New Exchequer Dam on the Merced River draws water from the bottom of the reservoir in the hypolimnion and water temperature management is complicated by the presence of three additional reservoirs downstream of New Exchequer that influence temperatures in the lower Merced River. Merced Irrigation District plans to investigate which option, if any, may exist to improve the water temperature regime in the lower river. Long-term agreements to adaptively manage reservoirs on these San Joaquin River tributaries are needed to provide the best possible flow and temperature conditions for fish habitat while also protecting the other existing beneficial water uses.

Another primary restoration need will be to maintain cool temperatures through the spring and again in the fall in the Delta and lower rivers to provide for upstream migrating adult and downstream migrating and rearing juvenile anadromous fish. Low flows either naturally occurring or caused by water storage or diversions are the problem in these areas. Although control of water temperature is limited in the lower rivers and the Delta, restoring natural flows, riparian vegetation, connecting marsh-sloughs, and reducing warm water discharges should benefit water temperatures in small but significant ways. Shallow water habitats with adequate shade will not locally warm to intolerable levels for species dependent on them. Dead-end sloughs will maintain slightly lower water temperatures with adequate shading. Minimizing discharges of warm water such as agricultural drains into rivers and Delta will help sustain cooler temperatures further into the spring and earlier into the fall. Although water temperature changes would be small, possibly less than an degree or two, such changes are significant when overall water temperatures are stressful or approach lethal levels for some species.

Although historical stream temperatures can be used as a guideline for establishing stream temperature targets, the actual management of temperatures for each tributary or river segment will require coordination with all agencies and stakeholders. Therefore, stream temperature targets should be developed within the existing multipurpose water resource management framework for each watershed. The relative ecological value of streamflow and temperature should be estimated for each tributary stream. Streamflow and temperature should be accurately monitored and rapidly evaluated for both short-term and long-term management decisions. This basic streamflow information will then allow for flexible management of streamflows. Flexible management will allow temperatures to become a major element in the restoration of ecological functions and benefits throughout the Sacramento and San Joaquin River basins.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Water temperature in Central Valley streams is being addressed under the Central Valley Improvement Act (CVPIA) subsection 3406(b) programs being administered by the USFWS. Water temperature is also addressed in various biological opinions and recovery plans (e.g., winter-run chinook salmon) for threatened and endangered species. Water temperature is also a common criteria in water quality standards for various rivers and the Delta.

There are several important ongoing programs that attempt to improve the multipurpose water management of Central Valley streamflows and temperature conditions. The vision for stream temperature management is to complement and coordinate (where conflicts exist) these existing streamflow and temperature management programs. Several agencies are directly or indirectly responsible for stream temperature management. ERPP supports the policies and decisions of these individual agencies and could provide resources to implement stream-temperature management actions and mediate conflicts between water management goals of individual agencies.

Important stream-temperature management responsibilities and programs of agencies include:

- DWR's operation of Lake Oroville to satisfy DFG hatchery and stream temperature objectives;
- Reclamation's operation of Central Valley Project reservoirs to achieve specific temperature criteria or objectives for salmon and steelhead habitat conditions;
- Federal Energy Regulatory Commission's regulation of minimum flows below hydropower projects throughout California (e.g., Butte Creek temperatures below Centerville Diversion Dam);
- SWRCB's administration of water rights and water quality objectives (in coordination with Regional Water Quality Control Boards) necessary for beneficial uses and for fish protection below reservoirs and dams;
- DFG's responsibility to study and recommend stream temperature requirements for fish protection and propagation in streams and at hatcheries;
- USFWS's and the National Marine Fisheries Service's programs to recommend temperatures needed for mitigation of impacts from federal projects (e.g., hatcheries) and protection of endangered species (the biological opinion for winter-run chinook salmon and the AFRP each have specific temperature recommendations and requirements); and
- USGS's water resources division programs to measure streamflow and temperature to provide the information necessary for adaptive management of stream temperatures.

Linkage to Multi-Species Conservation Strategy

Although the ERP treats water temperature as a separate ecological attribute, it is closely tied to a watershed's hydrologic pattern and is an important attribute of flowing water. The recovery of many aquatic species evaluated in the MSCS will be dependent on the ability or opportunity to provide not only the appropriate quantities of water at the appropriate time, but also provide water within certain specific temperature ranges. In many instances, the contemporary recommended flows and temperatures diverge greatly from historic unimpaired flow and temperature regimes. Regardless, stream temperature is an essential component of a healthy ecosystem that in many instances is closely tied to flow and storage patterns. The recovery of many species, particularly chinook salmon and steelhead stocks, is greatly dependent on stream temperature regimes that naturally fall or are managed within tight boundaries.

Linkage with Other Ecosystem Elements

Water temperature is a primary ecological process closely linked with other processes, habitats, and species. Water temperatures are dependent on streamflow and riparian vegetation. Stressors including water diversions and agricultural drainage discharges affect water temperature.

Objective, Targets, Actions, and Measures

The Strategic Objective for Central Valley stream temperature is to create and/or maintain flow and temperature regimes in rivers that support the recovery and restoration of native aquatic species.

Long-Term Objective: Native fish and invertebrate assemblages will be restored to regulated streams where feasible, using methods developed during the short-term objective phase.

Short-Term Objective: Provide adequate flows, temperatures, and other conditions to double the number of miles (as of 1998) of regulated streams that are dominated (>75% by numbers and biomass) by assemblages with four or more native fish species.

Rationale: Virtually all streams in the region are regulated to some degree, and the regulated flow regimes frequently favor non-native fishes. The native fish assemblages (including those with anadromous fishes) are increasingly uncommon. Recent studies in Putah Creek, the Stanislaus River, and the Tuolumne River demonstrate that native fish assemblages can be restored to sections of streams if flow (and temperature) regimes are manipulated in ways that favor their spawning and survival, usually by having flow regimes that mimic natural patterns in winter and spring but that increase flows during summer and fall months (to make up for loss of upstream summer habitats). Native invertebrates and riparian plants may also respond positively to these flow regimes. Achievement of this objective will require additional systematic manipulations of flows below dams (or the re-regulation of existing flow regimes) to determine the optimal flow and habitat conditions for native organisms, as part of the short-term goal. Part of the studies should be to determine if the objective can be achieved without "new" water, by just altering the timing of releases or by developing conjunctive use agreements that allow more water to flow down the stream channel. Ways to restore native fish communities that do not involve changed flows should be developed (where feasible) to be used in place of or synergistically with changed flows. These findings can then be applied opportunistically to achieve the long-term goal of restoring native fish communities.

Stage 1 Expectations: Surveys will have been completed to determine the status of native fishes in all regulated streams of the Central Valley and flow recommendations made to restore native fishes where feasible. During negotiations for relicensing of dams, agency personnel should evaluate and consider flow regimes favorable for native fishes.

Restoration Actions

General targets to achieve healthy Central Valley stream temperatures include:

- Maintaining water temperature at or below 56°F in salmon and steelhead spawning areas during spawning and incubation seasons below major dams on rivers. The ability of meeting this broad target will be influenced by in some drainages by the quantity and quality of coldwater stored behind the larger dams.

- Maintaining water temperature below 58°F for rearing and out-migrating salmon and steelhead from late winter through late spring.

- Maintaining water temperature below 60°F in oversummering areas of salmon and steelhead to the extent possible. When temperature control at this level is not possible, temperatures should be maintained below 65°F to avoid significant adverse impacts.

- Maintaining water temperature below 68°F in migratory routes of anadromous fish in spring and fall. Meeting this target in the lower Sacramento River, lower San Joaquin River, and in the Delta may be difficult in many years as there is no practical, short-term means by which to reduce water temperatures.

Several stream temperature actions should be implemented immediately. There is general agreement that these actions will improve stream temperatures without having significant impacts on water supply or energy resources. Many of these actions have been recommended by DFG and by AFRP but have not been implemented because of limited financial resources. They include:

- Increasing coldwater releases from Whiskeytown Lake to Clear Creek to allow restoration of the habitat along this 18-mile stream segment for salmon and steelhead spawning and rearing; Whiskeytown Lake could be coordinated with the operation of Shasta Dam to minimize impacts on the water supply;

- Developing a long-term agreement with Pacific Gas and Electric Company (to provide appropriate compensation for energy losses) to monitor temperatures and provide bypass flows in the lower North Fork and South Fork segments of Battle Creek to maintain suitable temperatures for holding, spawning, and rearing habitat for spring-run and winter-run chinook salmon and steelhead;

- Restoring stream temperature monitoring capability at several U.S. Geological Survey stream gages and other strategic locations of Central Valley streams, combined with improving fish sampling and counting devices to provide a solid basis for adaptive stream temperature management decisions; and

- Increasing Feather River flows in the "low-flow" channel to a maximum of 2,500 cubic feet per second (cfs) and reducing the flows through Thermalito Forebay and Afterbay released to the Feather River. Thermalito releases can have a major effect on downstream temperatures; only water needed for irrigation diversions and peaking power generation should be diverted (energy from the Thermalito power plant would be reduced).

Because temperatures are an important habitat condition and can vary with changes in other factors, there should be a substantial commitment to continued monitoring and evaluation of the physical, chemical, and biological processes and ecological functions that are governed by stream temperature.

Many stream-temperature management actions will require a slightly longer implementation period because additional information is needed for careful planning decisions, or because detailed designs for new or modified facilities are required. Nevertheless, the necessary planning studies and engineering design work can be initiated on the following longer term actions:

- Establish coordinated stream-temperature management teams for each major stream. Coordinated teams could follow the approach used by the Sacramento River Water Temperature Task Force to help Reclamation allocate and schedule releases for Sacramento River temperature control. This cooperative management approach attempts to maximize streamflow and temperature benefits while maintaining other beneficial uses of water. The choice between carryover storage and increased releases for temperature control can best be made by this type of adaptive management team. Potential conflicts between different fish populations and other water uses can also be addressed using this strategy.

- Restore blocks of riparian habitat that are sufficiently large (>50-100 acres) to create air convection currents, which will cool adjacent river water temperatures.

- Restore and protect the stream channels and riparian corridors (i.e., pools, gravelbeds, and vegetation). Minimizing warming along the stream gradient and providing habitat features will allow fish to use cool water areas in deep pools and springs.

- Develop a comprehensive series of reservoir and stream temperature models. The models would be used to investigate the effects of possible modifications to reservoir facilities and stream channel and riparian corridor conditions. These calibrated models can form the basis for adaptive management of Central Valley streamflows and temperatures within the overall framework of multipurpose water management objectives and constraints.

To protect and improve Central Valley stream temperatures, a responsible balance must be achieved between water management for temperature controls and other beneficial uses of the available water supply.

To be implemented, these measures may require that water from willing sellers be purchased or water exchanges negotiated and alternative supplies explored. There are two general programmatic actions:

- Provide sufficient carryover storage and selective withdrawal facilities in major reservoirs. These measures would help optimize summer and fall release temperatures to allow spawning and rearing of winter-run and fall-run salmon. A target temperature of 56°F during spawning and egg incubation is appropriate because salmon eggs have increasingly high mortality rates as temperatures rise above 56°F and total mortality above 68°F. The Shasta Reservoir temperature device is being constructed to allow warmer water to be released in spring and early summer to reserve more of the cooler water (at greater depth) for summer and fall releases. Because some carryover storage must be maintained to provide desirable temperatures downstream, specific reservoir releases for water supply may be reduced in some dry years.

- Provide sufficient summer and fall streamflows to maintain adequate holding and rearing temperatures for spring-run, fall-run, and winter-run salmon of less that 60°F in streams supporting these populations. This may require limiting hydropower diversions or providing higher reservoir releases than would otherwise be required for downstream diversions.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population goals. Although the measures were developed specifically for evaluated species, some measures have direct relationships to the manner in which stream temperatures influence habitat quality or have adverse effects on evaluated species.

- Initial species recovery efforts should be directed to locations where there are immediate opportunities for protection, enhancement, or restoration of suitable habitat.

- Coordinate protection, enhancement, and restoration of important habitats with other federal, state, and regional programs (e.g., the San Francisco Bay Area Wetlands Ecosystem Goals Project, the Anadromous Fish Restoration Program, and USFWS recovery plans) that could affect management of current and historic habitat use areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

- Implement management measures in the proposed recovery plan for the Sacramento River winter-run chinook salmon (National Marine Fisheries Service 1997).

- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program (U.S. Fish and Wildlife Service 1997) and the recovery plan for the native fishes of the Sacramento-San Joaquin Delta (U.S. Fish and Wildlife Service 1996).

- Continue research to determine causes for low outmigration survival of fish from the San Joaquin River in the South Delta and identify and implement measures to improve outmigration survival.

- Initially restore suitable valley/foothill riparian forest and woodland under the ERP along at least 10 contiguous miles in the Delta to create a riparian forest corridor at least 220 yards in width.
- Restore large contiguous blocks of suitable valley/foothill riparian forest and woodland at least 220 yards in width and 500 acres in size along reaches of the Sacramento River (Red Bluff to Colusa.

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